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The goal of this project was to investigate the field emission properties of laser-ablated hard carbon coatings. The Fowler-Nordheim description of field emission clearly demonstrates an exponential relationship between the field-emitted current and the geometry and work function of the emitter. Previous studies on the field emission measurements of hard carbons have been performed on nominally flat surfaces. Typically, a nominally flat surface is not smooth on the atomic scale, especially laser-ablated coatings that are prone to particulate contamination. This severely compromises the measurements resulting in inconsistent or incorrect measurements of the field emission characteristics which may be dominated by geometry of the surface rather than the material under test. We have taken an innovative approach to the measurement of the field emission by using micromachined substrates, tip arrays. The use of an array of 1000 (100 x 100), 1 micron molybdenum tips were fabricated using a Spindt-type process. The large number of tips statistically averages out the variations in the detailed morphology of the surface while the electric field enhancement of the tip permits testing at low voltages. An additional advantage is that the tip arrays use only a small fraction of the area for emission; the probability of a particulate from the deposition overlapping with an emission tip is very unlikely.

Carbon coatings were deposited on the molybdenum tip arrays using laser ablation. The thickness of the coating varied from 5 to 20 nm. The deposition rate was 2.5 nm/s. The deposition pressure was 10^{-6} Torr. Electron energy loss spectroscopy (EELS) showed significant sp^3 bonding which is diamond-like relative to sp^2 or graphite-like bonding.

The field emission characteristics were measured with an ion field emission microscope. All of the samples had excellent Fowler-Nordheim behavior, plots of the logarithm of the emission current divided by the square of the voltage versus the inverse of the voltage are linear. This indicates the tips are operating as field emitters.

The field emission characteristics of the uncoated tips were measured before being coated with the laser-ablated carbon. The field emission current of the as-coated tip arrays was found to be lower than the uncoated tips. This factor was as large as 50% and occurred for all coating thicknesses. This observation is in disagreement with many other reported observations in the literature.

The carbon coated tips were cleaned in a hydrogen plasma. This resulted in two significant effects. One, the emission current increased beyond the levels of the uncoated tips. This increase was small, in the order of 10%. Two, the emission stability of the carbon coated array was significantly enhanced. The stability is defined as the magnitude of the current fluctuations under constant bias conditions. We estimate this factor to be as large as a factor of 5. This effect is probable due to a greater chemical stability of the carbon surface with respect to adsorption and desorption of species form the background gasses.

We conclude that hydro-plasma cleaned, laser-ablated carbon coatings of field emission tips have demonstrated two important benefits. One, the magnitude of the emission current increases at fixed voltage. Two, stability of the emission is increased. Both of these results would be significant advantages for use in field emission flat panel displays.